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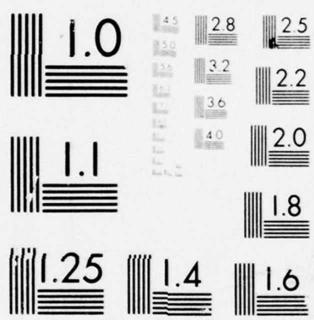

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NATIONAL BUREAU OF STANDARDS-1963-A

Report No. FAA-RD-77-159

Quarterly Technical Summary

Development of a Discrete Address Beacon System

1 October 1977

Prepared for the Federal Aviation Administration by

Lincoln Laboratory

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LEXINGTON, MASSACHUSETTS

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16. Abstract

This is the twenty-third Discrete Address Beacon System Quarterly Technical Summary. ~~covering the period 1 July through 30 September 1977.~~ Included are the results to date of analytical studies, laboratory and flight experiments, and software developments supporting the concept feasibility and performance definition phase of the FAA DABS Program.

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CONTENTS

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DEVELOPMENT OF A DISCRETE ADDRESS BEACON SYSTEM

I. INTRODUCTION AND PROGRAM OVERVIEW

A. Introduction

This is the twenty-third Quarterly Technical Summary covering work performed by Lincoln Laboratory between 1 July and 30 September 1977 to develop a Discrete Address Beacon System (DABS). This effort is supported by the Federal Aviation Administration through Interagency Agreement DOT-FA72-WAI-261 between the FAA and the United States Air Force.

DABS is an evolutionary upgrading of the present FAA ATC Radar Beacon System (ATCRBS) employing discretely addressable transponders and incorporating a ground-air-ground data link. DABS will provide the improved surveillance and communication capabilities required to meet the needs of an automated ATC system in the 1980's and 1990's.

Under Phase I, Lincoln Laboratory carried out a detailed system design of DABS based upon design studies, trade-off analyses, and experiments. This system design was described in a set of engineering requirements for engineering development models now being designed and fabricated by the Sensor Development Contractor (SDC), and to be evaluated at NAFEC. The completion of these requirements documents represented the nominal completion of Phase I.

During Phase II, Lincoln Laboratory is continuing to support the FAA as the DABS System Engineering Contractor (SEC). Major areas of responsibility during this phase include: validation and refinement of the designs specified, and assisting the FAA in monitoring the SDC.

B. Program Overview

Program highlights of the reporting period were:

(1) Completion of antenna pattern measurements on the first of two candidate L-band monopulse antennas (modified hogtrough) at the Elwood, New Jersey, ARSR-2 site.

(2) Reaching planned level of design effort on the Calibration and Performance Monitor Equipment (CPME units) slated for prototype sensor evaluation.

(3) Completion of initial stage of validating the performance of ARIES as interfaced with the DABS sensor at DABSEF.

C. Report Precis

Sections of this Quarterly Technical Summary contain Phase II task reports as follows:

Section II – FAA Support. In addition to its role as consulting monitor for the prototype DABS contractor (TI), Lincoln is supporting the FAA by (1) assisting NAFEC in the fabrication and test of monopulse beacon antennas for the en route radar at Elwood, New Jersey, and (2) providing DABS calibration and performance monitoring equipment for use with the three prototype sensors. The antenna task includes the modification of an existing beacon hogtrough antenna to add monopulse capability, and assessing its adequacy as installed on the ARSR-2 radar antenna. TMF-based measurements of monopulse direction finding accuracy on ATCRBS-controlled targets and targets-of-opportunity are required to

meet this objective. It is intended that the antenna selected be installed as either forward-looking or rearward-looking, in order to provide an increased data rate (back-to-back) mode.

The task of providing CPME equipment for use with the prototype sensors is essentially one of adapting an existing DABS transponder design (Bendix) to the continuous-duty, ground-environment, monitoring function required.

Section II provides descriptive and status information on both of the above tasks. Typical antenna patterns measured at NAFEC are included, as is a preliminary description of the CPME hardware.

Section III – Aircraft Reply and Interface Environment Simulator. One Aircraft Reply and Interference Environment Simulator (ARIES) equipment is to be provided by Lincoln for validation tests of DABS sensors under simulated maximum specified DABS and ATCRBS interrogation and fruit loading. This two-rack, minicomputer-based hardware is presently being exercised in conjunction with the experimental DABS sensor at DABSEF. Section III provides a summary of the present operating status and briefly describes problem areas and subsystems still being tested.

Also included in Section III is an explanation of the procedure of ARIES monopulse calibration and a sample of the look-up table relating off-boresight angle and ARIES output channel digital attenuator "counts."

Section IV – Experimental Facilities. A brief activity summary is provided for the DABSEF, the DABS avionics, and the TMF. DABSEF continues as a data reduction center, several DABS transponders are being diverted to CPME and BCAS service, and the TMF is in the midst of monopulse antenna evaluation measurements at Elwood, New Jersey.

II. FAA SUPPORT

A. DABS En Route Sensor Back-to-Back Antenna

1. Background

One of the three DABS prototype sensors is scheduled to be installed at the FAA en route test facility at Elwood, New Jersey. This facility currently contains an AT309C beacon hogtrough antenna mounted atop an ARSR-2 radar reflector. The antenna system is enclosed within a 55-ft-dia. radome. Lincoln Laboratory is tasked with the responsibility of recommending an interim DABS back-to-back antenna system for Elwood which can be implemented with minimum cost and which could be available at the time of the prototype sensor delivery.

A possible interim back-to-back antenna configuration for Elwood would use, as one of the antennas, the existing hogtrough suitably modified for monopulse. Consideration of the hogtrough, particularly in its present location, raises two questions related to monopulse direction finding accuracy:

(a) What is the effect of the nearby radome surface on tracking accuracy, and

(b) Independent of the radome problem, are the patterns of a modified hogtrough antenna generally suitable for a DABS monopulse sensor?

This section presents the results of pattern measurements performed on the modified hogtrough antenna at Elwood on 18 August 1977. Full-azimuth sum and difference patterns over a variety of elevation angles were generated from TMF reply data recorded on an aircraft radial flight. Additional ATCRBS surveillance data was recorded on targets-of-opportunity in order to determine more directly through track statistics the effect of the radome and the antenna monopulse characteristics on direction-finding accuracy. These data are currently being processed.

2. Hogtrough Modification for Monopulse

The Elwood hogtrough antenna, designated AT309C, is a four-section antenna with each section fed independently from a four-output power divider unit mounted on the antenna. The conversion to monopulse capability was accomplished by replacing the original power divider box with a unit designed to provide a sum and difference output (Fig. II-1). The power fed to the outboard section is attenuated 6 dB relative to the inboard sections in accordance with the design of the original divider unit.

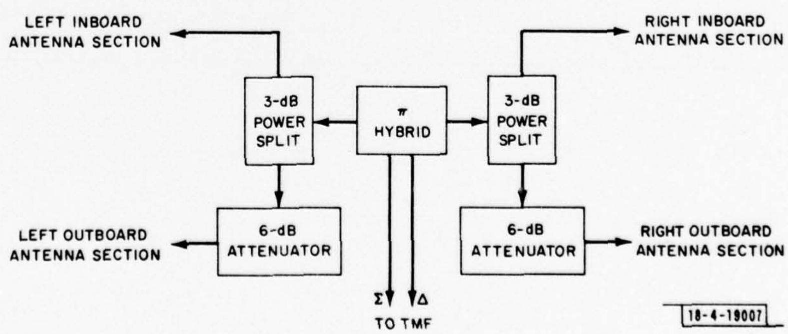

Fig. II-1. Elwood hogtrough monopulse modification.

TABLE II-1

SUMMARY OF MODIFIED HOGTROUGH ANTENNA PATTERN DATA
(3000-ft Altitude, Radial)

Elevation Angle	3-dB Sum Beamwidth	Sum Peak Sidelobe WRT Sum Peak	Sum Average Backlobe WRT Sum Peak	Difference Lobes WRT Sum			Crossover Separation	Difference Peak Sidelobe WRT Difference Peak	10-dB Difference Beamwidth	20-dB Difference Beamwidth	Difference Average Backlobe WRT Sum Peak
				Rt	Lt	Δ					
Deg	Deg	−dB	−dB	−dB	−dB	dB	Deg	−dB	Deg	Deg	−dB
40	2.5	18	30	3.3	4.7	1.4	3	9	12	26	32
30	2.3	21	31	2.7	5.3	2.5	2.7	11	9.7	16	31
20	2.2	19	33	2.7	4.7	2	2.7	11	7.3	23	33
15	2.2	22	35	2.7	4.7	2	2.4	11	8	21	34
12.5	2.2	21	34	2.7	4.7	2	2.5	10	8.5	14	32
10	2.2	22	32	2.7	4.7	2	2.6	12	7.8	14	31
7	2.3	20	31	2.7	4.7	2	2.6	11	7	14	30
5	2.0	18	30	2.7	6	3.3	2.6	12	7	20	30
4	2.0	21	31	3.3	5.3	2	2.7	10	8	17	31
3	2.0	20	–	3.3	4.3	1	2.4	11	7	12	–
2	2.0	18	–	2.7	4.7	2	2.4	13	7	–	–
1	2.0	18	–	2.7	4.7	2	2.5	13	7	–	–
0.5	2.2	–	–	2.7	–	–	2.5	–	–	–	–
Avg	2.2	20	32	2.9	4.9	2	2.6	11	–	–	32
0	1.8	21	–	1.5	4	2.5	2.1	12	7	17	–

3. Flight Plan and Data Recording

Recording of hogtrough pattern data was made by flying a Mode D-equipped aircraft on two different radial flight paths. One radial was flown at a constant altitude of 3000 ft out to a range of 40 nmi providing continuous azimuth pattern cuts ranging from elevation angles of 40° to 0.5°. The other radial was flown at an altitude of 12,000 ft out to a range of 20 nmi (45° to 10° elevation). The terrain under the flight path was mostly wooded and fairly flat as is typical of the coastal region of southern New Jersey.

The aircraft was interrogated via a stationary standard-gain horn pointed along the radial flight path. Mode D interrogations at 360 prf (with no P_2) were used to provide both a "cleaner" downlink recording environment and to prevent over-interrogation of other aircraft.

Continuous recording of the downlink reply pulse sum and difference amplitudes were accomplished by using the TMF receiver and recording system. All of the pattern data were taken with a dry radome condition.

The TMF tapes were processed to provide single 360° azimuth sum and difference patterns from elevations of 45° to essentially 0°.

4. Test Results

In order to reduce the voluminous data, values associated with selected pattern characteristics were chosen for tabulation as a function of elevation angle. These values are listed in Tables II-1 and -2. Figures II-2 through -5 were selected as typical of the sum and difference amplitude plots from which the tabulated data were derived. Table II-3 summarizes the performance observed.

5. Conclusions

From the data, it appears that the proximity of the radome and the orientation of its surface with respect to the target angle have no noticeable effect on the structure of the monopulse patterns. It is, however, not yet established that there is no effect on the monopulse direction-finding accuracy. As mentioned earlier, target-of-opportunity data for both a wet and dry radome are currently being processed for tracking statistics on selected targets at various elevation angles and ranges.

B. Calibration and Performance Monitor Equipment

The DABS Calibration and Performance Monitor Equipment (CPME) is a modified DABS transponder packaged for installation at a fixed site visible to one or more DABS sensors. Lincoln Laboratory is to build four units for delivery to NAFEC in 1978.

1. Description of the CPME

Each CPME consists (see Fig. II-6) of an environmentally protected horn antenna, a modified Bendix DABS transponder, additional receiver components, an auxiliary power amplifier, a special ultrastable oscillator used as the transmitter source, additional control and diagnostic logic, and power supplies. Except for the antenna, these components are all mounted within a special weathertight enclosure suitable for outdoor stand-alone operation.

Mode decoding and reply encoding are performed by unaltered transponder circuitry, hence the CPMEs will have the same communication capability as the DABS transponders. The

TABLE II-2

SUMMARY OF MODIFIED HOGTROUGH ANTENNA PATTERN DATA
(12,000-ft Altitude, Radial)

Elevation Angle	3-dB Sum Beamwidth	Sum Peak Sidelobe WRT Sum Peak	Sum Average Backlobe WRT Sum Peak	Difference Lobes WRT Sum			Crossover Separation	Difference Peak Sidelobe WRT Difference Peak	10-dB Difference Beamwidth	20-dB Difference Beamwidth	Difference Average Backlobe WRT Sum Peak
				Rt	Lt	Δ					
Deg	Deg	−dB	−dB	−dB	−dB	dB	Deg	−dB	Deg	Deg	−dB
45	3.0	18	–	3	4.7	1.7	3.6	11	11.0	>30	–
40	2.6	23	–	4	5.3	1.3	3.3	10	9.7	–	–
35	2.2	17	–	3	4.7	1.7	2.8	11	9.2	–	–
30	2.6	20	–	2.5	4	1.5	2.8	13	9.3	18	–
25	2.5	22	–	2.7	4	1.3	2.8	10	8.4	19	–
20	2.0	18	–	2.7	4.7	2.0	2.6	11	7.4	22	–
15	2.3	21	–	2.7	5	2.3	2.7	12	7.2	18	–
10	2.0	21	–	3.3	5.3	2.0	2.7	12	7.2	–	–
Avg	2.4	20	–	3	4.7	1.7	2.9	11	–	–	–

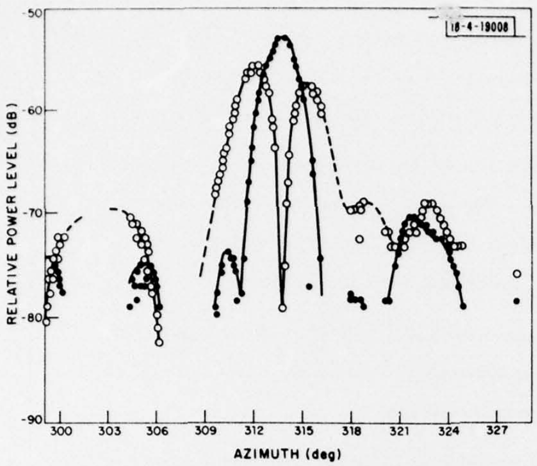

Fig. II-2. Modified hogtrough antenna pattern, elevation angle: 2 deg.

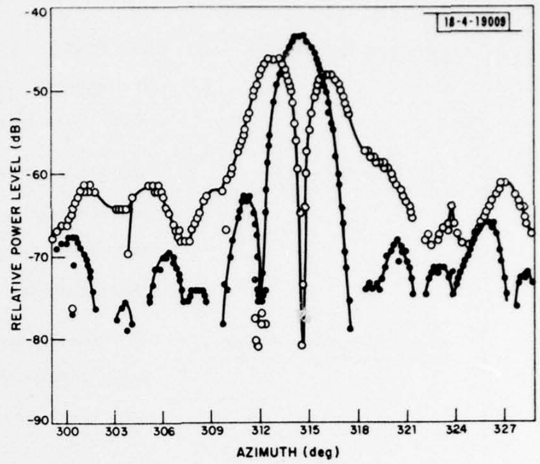

Fig. II-3. Modified hogtrough antenna pattern, elevation angle: 7 deg.

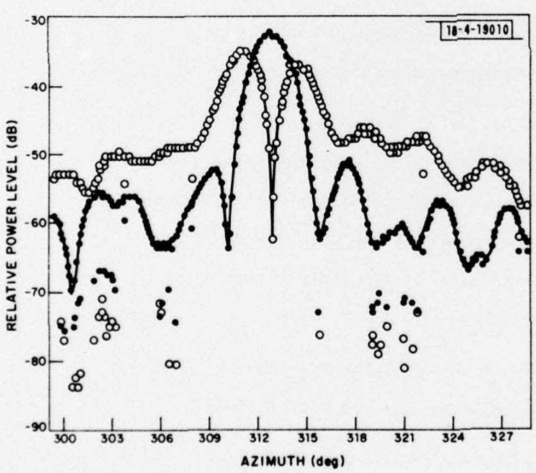

Fig. II-4. Modified hogtrough antenna pattern, elevation angle: 20 deg.

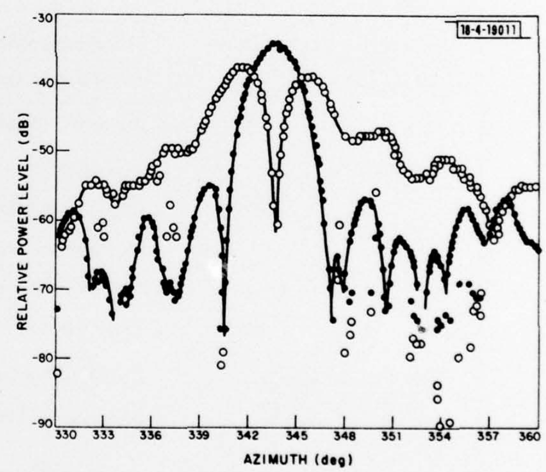

Fig. II-5. Modified hogtrough antenna pattern, elevation angle: 40 deg.

TABLE II-3

MODIFIED HOGTROUGH MEASURED PERFORMANCE

3-dB Sum Beamwidth	The measured sum beamwidth broadens slightly as elevation angle is increased, varying from 2° at low angles to 3° at 45° elevation. (Specification: 2.4° at 3-dB sum beamwidth).
Sum Peak Sidelobes	The sum peak sidelobe level does not appear to be influenced by elevation angle. The average of the peak value over the elevation angle range is 20 dB with a ±2 dB variation. (Specification: sum sidelobe level, 26 dB).
Sum Average Backlobes	The average sum backlobe level (defined as the average of all lobes outside of the two adjacent sidelobes) was about −32 dB with respect to the maximum sum.
Difference Peak Levels	A definite asymmetry* of 2 dB exists between the right and left peak lobes of the difference pattern with the right lobe (as viewed from behind the antenna) always higher and no dependency on elevation angle.
Separation Between Sum and Difference Crossover Points	The separation between crossover points increases slightly for for higher elevation angles.
Difference-Pattern Peak Sidelobe Level	The difference-pattern peak sidelobe level is approximately 11 dB below the maximum difference lobe and independent of elevation angle.†
Difference-Pattern Beamwidth 10 dB and 20 dB Below Peak	This is an alternative way of indicating the high sidelobe levels and mainlobe broadening that result when the amplitude distribution across the antenna aperture is not optimally tapered. These difference pattern values are very close to those associated with the Cossor antenna.
Difference-Pattern Average Backlobe Level	Computed in the same manner as the sum backlobe levels and approximately equivalent to the sum backlobes.

*Asymmetry believed to be due to phase unbalance within the antenna.

†The high difference sidelobes are typical of an antenna in which no attempt is made to optimize the difference pattern by an amplitude taper that is independent of the sum distribution.

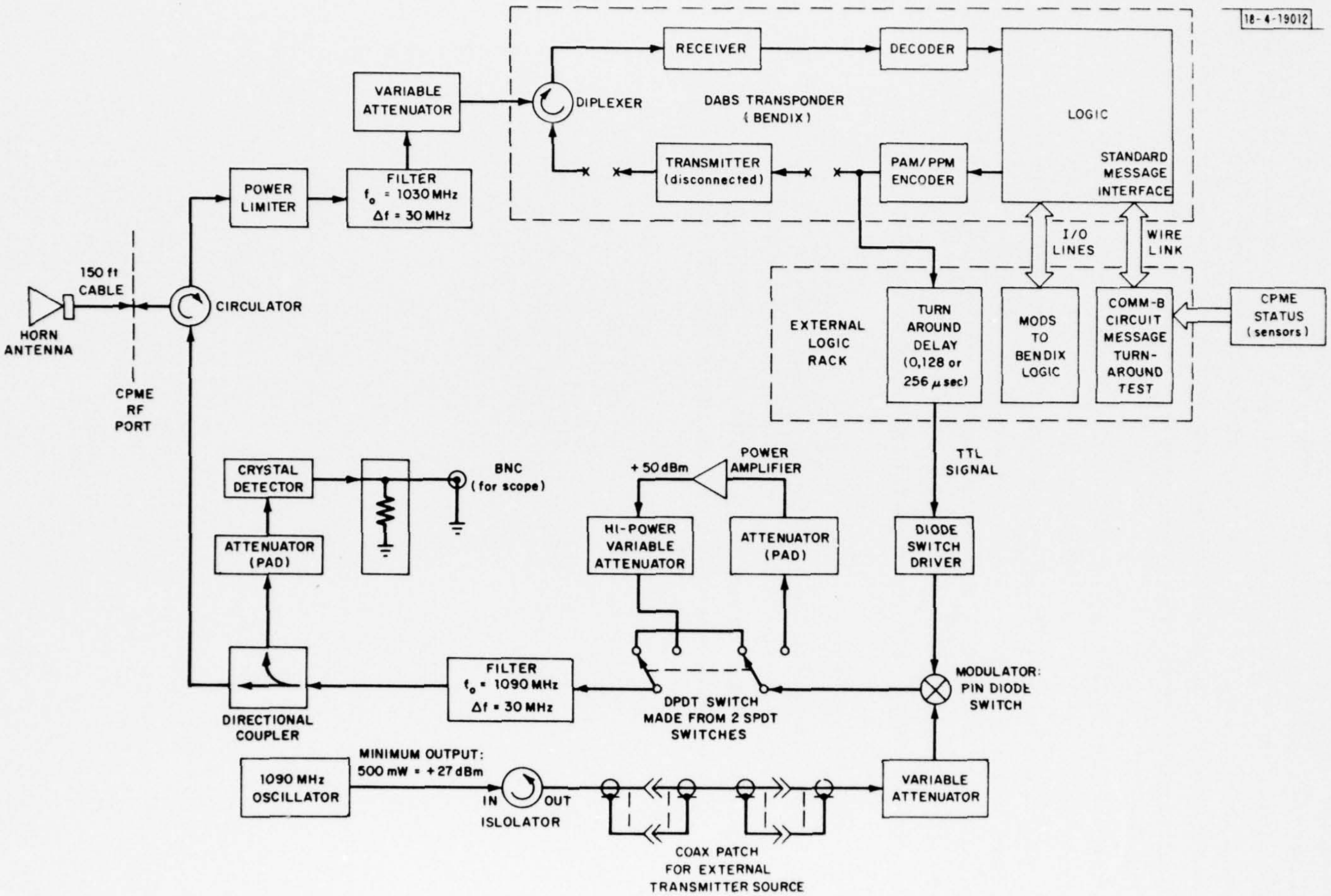

Fig. II-6. Calibration and performance monitor equipment, block diagram.

DABS transponder receiver section is also employed, but front-end protection, out-of-band filtering, and variable input attenuation have been added. The transponder's built-in transmitter and power supplies are not used. A pin diode modulated stable oscillator operating with or without an auxiliary power amplifier permits the CPME to be placed up to 20 nmi from the sensor in the high-power mode, or 2000 ft from the sensor in the low-power mode. The high-power mode is particularly useful if the CPME is to be shared with more than one sensor (in this case more than one directional horn antenna would be fed from one CPME). Provisions are incorporated to allow an external variable frequency signal source to replace the ultrastable oscillator during acceptance testing.

The additional control and diagnostic logic enable the CPME to conform to lockout requirements, to reply with 128 or 256 μsec additional turnaround delay, to operate in a test mode in which the CPME "parrots" uplink messages, to turn off the power amplifier power supply when it is not needed, and to protect the amplifier from excessive duty cycle. Status reporting provisions are included to transmit (as a Comm-B downlink message): enclosure over-and-under temperature, 1090-MHz oscillator out-of-phase-lock condition, power failure condition, and interrogation lockout states. The entire status reporting system can be inhibited if desired.

2. CPME Design Status

The CPME RF design is essentially complete, and all RF parts have been ordered. A one-to-one mechanical (paper) mockup is complete, showing placement of all components and how they will fit into the enclosure. Several subdivisions of the CPME logic have been designed and are now in the debugging stage; preliminary or detailed designs exist for the rest of the logic subdivisions.

III. ARIES SIMULATOR

A. ARIES Checkout with the DABSEF Sensor

The ARIES simulator (see Fig. III-1) was connected to the DABS sensor at DABSEF on 12 July 1977.

ARIES currently generates discrete, All-Call and ATCRBS targets with good azimuth stability (±4 Au, or ±0.088° as measured by the DABSEF sensor) and excellent range stability. Targets currently are input via the teletype, but the coding for the disk input task is complete and will shortly allow target models to be input from the disk. Targets move correctly indicating that the scan-to-scan updating of target positions operates properly.

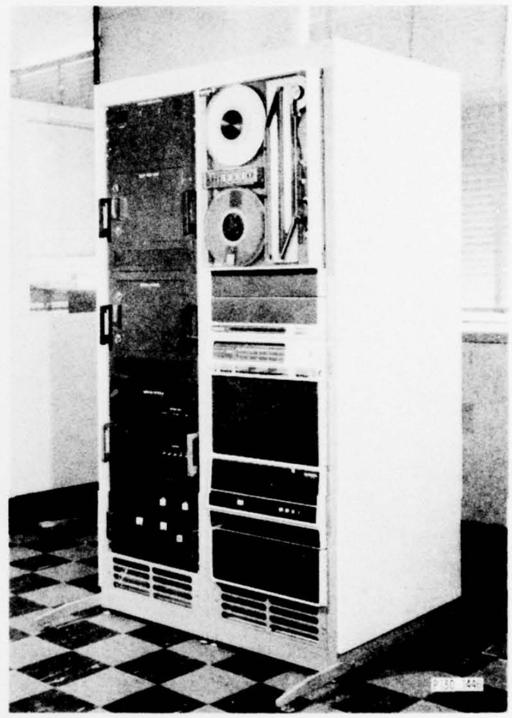

Fig. III-1. ARIES equipment.

A few hardware problems were resolved shortly after ARIES was moved to DABSEF, and little hardware activity has been required since that time. A known problem remains with the amplitude measurements made by the self-test unit, believed to be caused by a noise source within the tester itself. Work on this has been deferred to date to allow software development to proceed, as it was clear from the monopulse results that the reply generator amplitudes were correct. The radar report generator has not been tested, but it has been used successfully in the past, so no debugging should be required. Both of these matters should be taken care of during the next month.

A current software problem is that core size limits the system to only 10 tracks. The excess core size requirement appears to be due to: (1) an incomplete understanding of the complexity of some of the software, (2) the inefficiency of the FORTRAN compiler being used, and (3) the fact that the operating system requires an excessively large minimum stack size for each

MONOCAL

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ENTER NUMBER OF SAMPLES PER ATTENUATOR SETTING30
MONOPULSE DATA. THE MONOPULSE COUNT IS IN OCTAL.
DATA IS IN DECIMAL AZIMUTH UNITS. NEGATIVE NUMBERS ARE LEFT OF BORESIGHT
LR BIT = 0

COUNT	0	1	2	3	4	5	6	7	10	11	12	13	14	15	16	17
0	~~273~~	~~273~~	~~273~~	~~273~~	~~273~~	~~273~~	~~273~~	~~273~~	~~273~~	~~273~~	-70	-69	-68	-67	-67	-66
20	-65	-64	-63	-62	-62	-60	-60	-59	-59	-57	-57	-56	-55	-55	-54	-53
40	-53	-51	-51	-50	-49	-49	-48	-48	-47	-46	-45	-45	-44	-44	-43	-43
60	-42	-42	-41	-40	-40	-39	-39	-39	-38	-37	-36	-36	-36	-35	-35	-34
100	-34	-33	-32	-32	-32	-31	-31	-31	-30	-29	-29	-29	-28	-28	-27	-27
120	-27	-27	-26	-26	-25	-25	-25	-24	-24	-24	-23	-23	-22	-22	-22	-22
140	-21	-21	-20	-20	-20	-20	-19	-19	-19	-19	-18	-18	-18	-18	-17	-17
160	-17	-16	-16	-16	-16	-16	-15	-15	-15	-15	-14	-14	-14	-14	-13	-13
200	-13	-13	-13	-13	-13	-13	-12	-12	-12	-12	-11	-11	-11	-11	-11	-11
220	-11	-10	-10	-10	-10	-10	-10	-10	-10	-9	-9	-9	-9	-9	-8	-9
240	-8	-8	-8	-8	-8	-8	-8	-8	-7	-7	-7	-7	-7	-7	-7	-7
260	-6	-6	-6	-6	-6	-6	-6	-6	-6	-5	-5	-5	-5	-5	-5	-5
300	-5	-5	-5	-5	-5	-5	-4	-5	-4	-4	-4	-4	-4	-4	-4	-4
320	-4	-4	-4	-4	-4	-3	-4	-3	-3	-4	-3	-4	-3	-3	-3	-3
340	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3
360	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2

LR BIT = 1

COUNT	17	16	15	14	13	12	11	10	7	6	5	4	3	2	1	0
360	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
340	2	2	2	2	2	3	2	3	3	3	3	3	3	3	3	3
320	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4
300	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5
260	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	7
240	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8
220	9	9	9	9	9	9	9	9	10	10	10	10	10	10	10	11
200	11	11	11	11	11	12	12	12	12	12	12	12	13	13	13	13
160	13	13	14	14	14	14	14	15	15	15	15	15	16	16	16	17
140	17	17	17	17	18	18	18	19	19	19	19	20	20	20	21	21
120	21	21	22	22	22	23	23	23	24	24	24	25	25	25	25	26
100	27	27	27	27	28	28	28	29	29	30	30	30	31	31	32	33
60	33	34	34	34	35	35	36	36	37	37	38	38	39	39	40	40
40	41	41	42	43	43	44	44	45	46	46	48	47	48	49	49	50
20	51	51	52	52	53	54	55	55	56	58	58	58	60	59	61	61
0	63	63	63	65	65	66	67	68	70	70	71	71	72	73	74	75

STOP

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Fig. III-2. Sample ARIES monopulse calibration table.

task causing about 4K words to be occupied by the stacks. A variety of options are available for reducing the core size and stack requirements, and there appears to be no problem in reaching the 400-target level.

The ARIES "Principles of Operation" manual is progressing satisfactorily; a draft will be available shortly.

B. Monopulse Calibration

In order for ARIES to be able to generate off-boresight simulated replies whose amplitude and phase correspond to known angular offsets, ARIES must be calibrated against the particular DABS sensor with which it will operate. In the period since the prototype ARIES has been operated with DABSEF, this calibration procedure has been completed for the first time. Figure III-2 shows the monopulse calibration table obtained.

Each entry in the calibration table represents an off-boresight angle (expressed in azimuth units*) plotted against ARIES digital attenuator setting in counts (base of 8). Counts of 0 and 377 correspond to $\Sigma = \Delta$ (sum- and difference-channel outputs equal) and Δ-null, respectively. Negative off-boresight angles (top half) are to the left of boresight and positive values to the right.

The table was obtained by arranging for the DABS sensor at DABSEF to interrogate ARIES continuously at a slow rate. For each interrogation received, ARIES replied with a different off-boresight angle, proceeding incrementally from left to right of boresight.† For each reply received, the measured off-boresight angle was obtained by the DABS sensor using its own monopulse table. The measured off-boresight angle was sent to ARIES via the next interrogation. At the end of the test, ARIES had gathered a table of angle offsets as seen by the DABS sensor that correspond to the settings of the attenuator.

*To obtain azimuth offset angle in degrees, multiply by $360/2^{14}$ or by 0.022°.

†ARIES simulates off-boresight angle by changing the gain setting of the difference (Δ) channel with respect to the sum (Σ) channel. This is accomplished by means of an 8-bit digitally controlled attenuator. Each bit represents 0.125 dB attenuation of the difference channel with respect to the sum channel, and 0 corresponds to $\Delta = \Sigma$. The sign of the off-boresight angle is simulated by digitally controlling a 180° phase shifter (LR = 0 and LR = 1 corresponds to left and right of boresight, respectively).

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IV. EXPERIMENTAL FACILITIES

A. DABSEF

In addition to serving as the DABS Program data processing center, since July DABSEF has served as the test bed for the initial alignment, calibration, and integration testing of the ARIES simulator. Data processing activities have included processing of TMF data from Elwood, New Jersey, and reprocessing of TMF data from previous sites.

Miscellaneous support activities during the period have included briefing NAFEC personnel on DABSEF data reduction software and assisting a film crew in shooting scenes of control room operations and various views of the facility.

B. Avionics

In the absence of major ongoing flight programs, the remaining transponders have been assigned to other DABS-related tasks. Four of the units will ultimately become part of the CPMEs while two have been and will continue to be operated for the BCAS program. Appropriate modifications have been made, and sufficient data have been supplied to those involved in these projects to ease the transition and the modifications.

For future use, a new set of transponders, similar to and interchangeable with the existing equipment will have to be procured. The specifications for this new set have been written up with careful attention to the DABS National Standard and the requirements of future test programs.

In anticipation of upcoming data-link projects, some hardware has been assembled which will form an interactive universal terminal and display in DABS-equipped aircraft. This work is still in process; first anticipated use of the equipment will be for the ATARS project which needs a flexible, programmable display device.

C. TMF

On 9 August 1977, the TMF was moved to the NAFEC en route experimental site at Elwood, New Jersey, for the purpose of testing two candidate antenna systems potentially useful in a back-to-back antenna system for the Elwood DABS prototype sensor. The two antennas are an AT309C beacon antenna and a NADIF feed, both modified to have a monopulse capability.

The data recording configuration at Elwood consists of the TMF monopulse receiver, digital circuitry and recording system coupled to the candidate back-to-back antenna system under test. Data have already been gathered on a modified hogtrough antenna. The data consisted of antenna monopulse patterns derived from aircraft radial flights and normal TMF edge-event recordings of targets of opportunity. The hogtrough pattern test results are presented in Section II-A of this summary report. The target-of-opportunity data to be gathered to provide tracking statistics for evaluation of direction-finding accuracy using the modified antenna will be presented later.

The modified NADIF antenna will be evaluated in the same manner by recording and processing antenna patterns and target-of-opportunity data. In addition, because of the large vertical separation between the NADIF system and the omni antenna at Elwood, radial flights will be made to determine the extent of differential lobing between the two antennas.

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DABS DOCUMENTS ISSUED BY LINCOLN LABORATORY

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Quarterly Technical Summaries

FAA-RD-72-44	QTS 1	1 April 1972	Development of a Discrete Address Beacon System
FAA-RD-72-76	QTS 2	1 July 1972	Development of a Discrete Address Beacon System
FAA-RD-72-117	QTS 3	1 October 1972	Development of a Discrete Address Beacon System
FAA-RD-73-12	QTS 4	1 January 1973	Development of a Discrete Address Beacon System
FAA-RD-73-48	QTS 5	1 April 1973	Development of a Discrete Address Beacon System
FAA-RD-73-101	QTS 6	1 July 1973	Development of a Discrete Address Beacon System
FAA-RD-73-165	QTS 7	1 October 1973	Development of a Discrete Address Beacon System
FAA-RD-74-8	QTS 8	1 January 1974	Development of a Discrete Address Beacon System
FAA-RD-74-85	QTS 9	1 April 1974	Development of a Discrete Address Beacon System
FAA-RD-74-136	QTS 10	1 July 1974	Development of a Discrete Address Beacon System
FAA-RD-74-167	QTS 11	1 October 1974	Development of a Discrete Address Beacon System
FAA-RD-75-4	QTS 12	1 January 1975	Development of a Discrete Address Beacon System
FAA-RD-75-67	QTS 13	1 April 1975	Development of a Discrete Address Beacon System
FAA-RD-75-114	QTS 14	1 July 1975	Development of a Discrete Address Beacon System
FAA-RD-75-166	QTS 15	1 October 1975	Development of a Discrete Address Beacon System
FAA-RD-76-10	QTS 16	1 January 1976	Development of a Discrete Address Beacon System
FAA-RD-76-82	QTS 17	1 April 1976	Development of a Discrete Address Beacon System
FAA-RD-76-126	QTS 18	1 July 1976	Development of a Discrete Address Beacon System
FAA-RD-76-174	QTS 19	1 October 1976	Development of a Discrete Address Beacon System
FAA-RD-77-7	QTS 20	1 January 1977	Development of a Discrete Address Beacon System

FAA-RD-77-64	QTS 21	1 April 1977	Development of a Discrete Address Beacon System
FAA-RD-77-107	QTS 22	1 July 1977	Development of a Discrete Address Beacon System
FAA-RD-77-159	QTS 23	1 October 1977	Development of a Discrete Address Beacon System

Project Reports

FAA-RD-72-7	ATC-8	24 January 1972	Interrogation Scheduling for the Discrete Address Beacon System	E. J. Kelly
FAA-RD-72-30	ATC-9	12 April 1972	Final Report, Transponder Test Program	G. V. Colby E. A. Crocker
FAA-RD-72-84	ATC-12	14 August 1972	A Comparison of Immunity to Garbling for Three Candidate Modulation Schemes for DABS	D. A. Shnidman
FAA-RD-72-77	ATC-13	14 August 1972	Parallel Approach Surveillance	J. B. Allen E. J. Denlinger
FAA-RD-72-100	ATC-15	29 November 1972	The Influence of Surveillance System Parameters on Automated Conflict Detection and Resolution	J. W. Andrews G. Prado
FAA-RD-73-126	ATC-19	17 October 1973	Interrogation Scheduling Algorithms for a Discrete Address Beacon System	A. Spiridon A. D. Kaminsky
FAA-RD-74-4	ATC-20	28 January 1974	The Effects of ATCRBS P_2 Pulses on DABS Reliability	W. H. Harman D. A. Shnidman
FAA-RD-74-20	ATC-22	19 February 1974	Summary of Results of Antenna Design Cost Studies	J-C. Sureau
FAA-RD-73-160	ATC-25	28 November 1973	DABS/ATCRBS Transponder Bench Testing Program	J. R. Samson J. D. Welch E. R. Becotte E. A. Crocker H. D. Schofield
FAA-RD-74-17	ATC-27	1 March 1974	A Summary of the DABS Transponder Design/Cost Studies	T. J. Goblick P. H. Robeck
FAA-RD-74-142	ATC-29	13 December 1974	DABS Timing: Clocks, Synchronization and Restart	E. J. Kelly
FAA-RD-73-175	ATC-30	9 November 1973	Provisional Signal Formats for the Discrete Address Beacon System	P. R. Drouilhet Editor
FAA-RD-74-62	ATC-30 Rev. 1	25 April 1974	Provisional Signal Formats for the Discrete Address Beacon System (Revision 1)	P. R. Drouilhet Editor
FAA-RD-74-5	ATC-31	13 February 1974	Report on DABS/ATCRBS Field Testing Program	J. R. Samson, Jr. E. A. Crocker

FAA-RD-74-21	ATC-32	4 February 1974	The Effect of Phase Error on the DPSK Receiver Performance	D. A. Shnidman
FAA-RD-74-63	ATC-33	25 April 1974	Provisional Message Formats for the DABS/NAS Interface	D. Reiner H. F. Vandevenne
FAA-RD-74-63A	ATC-33 Rev. 1	10 October 1974	Provisional Message Formats for the DABS/NAS Interface (Revision 1)	D. Reiner H. F. Vandevenne
FAA-RD-74-64	ATC-34	25 April 1974	Provisional Data Link Interface Standard for the DABS Transponder	G. V. Colby P. H. Robeck J. D. Welch
FAA-RD-74-83	ATC-35	24 May 1974	Provisional Message Formats and Protocols for the DABS IPC/PWI Display	P. H. Robeck J. D. Welch
FAA-RD-74-84	ATC-36	20 May 1974	Provisional Message Formats and Protocols for the DABS 32-Character Alphanumeric Display	J. D. Welch G. V. Colby
FAA-RD-74-144	ATC-37	15 January 1975	An Analysis of Aircraft L-Band Beacon Antenna Patterns	G. J. Schlieckert
FAA-RD-74-145	ATC-38	13 December 1974	Further Studies of ATCRBS Based on ARTS-III Derived Data	A. G. Cameron
FAA-RD-74-162	ATC-40	4 March 1975	DABS Uplink Encoder	J. R. Samson
FAA-RD-74-186	ATC-41	28 April 1975	DABS Link Performance Considerations	G. J. Schlieckert
FAA-RD-74-189	ATC-42	18 November 1974	DABS: A System Description	P. R. Drouilhet
FAA-RD-74-197	ATC-43	8 January 1975	DABS Channel Management	E. J. Kelly
FAA-RD-75-75	ATC-44	16 May 1975	Model Aircraft L-Band Beacon Antenna Pattern Gain Maps	D. W. Mayweather
FAA-RD-75-8	ATC-45	16 May 1975	Network Management	H. F. Vandevenne
FAA-RD-75-210	ATC-46	June 1975	Plan for Flight Testing Intermittent Positive Control	J. W. Andrews J. F. Golden J. C. Koegler A. L. McFarland M. E. Perie K. D. Senne
FAA-RD-75-23	ATC-47	4 April 1975	Scale Model Pattern Measurements of Aircraft L-Band Antennas	K. J. Keeping J-C. Sureau
FAA-RD-75-61	ATC-48	12 September 1975	DABS Downlink Coding	J. T. Barrows
FAA-RD-75-62	ATC-49	25 July 1975	DABS Uplink Coding	J. T. Barrows
FAA-RD-75-91	ATC-50	17 July 1975	Impact of Obstacle Shadows on Monopulse Azimuth Estimate	A. Spiridon

FAA-RD-75-92	ATC-51	20 February 1976	DABS Sensor Interactions with ATC Facilities	D. Reiner H. F. Vandevenne
FAA-RD-75-93	ATC-52	12 March 1976	DABS Modulation and Coding Design – A Summary	T. J. Goblick
FAA-RD-75-112	ATC-53	3 February 1976	Summary of DABS Antenna Studies	J-C. Sureau
FAA-RD-75-113	ATC-54	2 February 1976	Design Validation of the Network Management Function	P. Mann H. F. Vandevenne
FAA-RD-75-145	ATC-56	14 November 1975	Discrete Address Beacon System (DABS) Test Plan for FY 1976	W. H. Harman D. Reiner V. A. Orlando
FAA-RD-76-22	ATC-57	16 March 1976	IPC Design Validation and Flight Testing – Interim Results	J. W. Andrews J. C. Koegler
FAA-RD-75-233	ATC-60	25 March 1976	The Airborne Measurement Facility (AMF) System Description	G. V. Colby
FAA-RD-75-234	ATC-61	9 June 1976	Empirical Characterization of IPC Tracker Performance Using DABS Data	J. Leeper A. Tvirbutas
FAA-RD-76-2	ATC-62	23 March 1976	Beacon CAS (BCAS) – An Integrated Air/Ground Collision Avoidance System	V. A. Orlando J. D. Welch
FAA-RD-76-39	ATC-65	31 January 1977	The ATCRBS Mode of DABS	J. L. Gertz
FAA-RD-76-219	ATC-72	4 February 1977	DABS Monopulse Summary	D. Karp M. L. Wood
FAA-RD-77-30	ATC-73	25 April 1977	Air-to-Air Visual Acquisition Performance with Pilot Warning Instruments (PWI)	J. W. Andrews
FAA-RD-77-77	ATC-75	16 August 1977	DABS Coverage	S. I. Krich
FAA-RD-77-78	ATC-76	7 June 1977	Effects of RF Power Deviations on BCAS Link Reliability	W. H. Harman
FAA-RD-77-87	ATC-77	6 September 1977	L-Band Air-to-Air Multipath Measurements	A. Paradis
FAA-RD-77-92	ATC-78	19 September 1977	A Hardware Implementation of the ATCRBS Reply Processor Used in DABS	R. G. Nelson J. H. Nuckols

Technical Notes

1972-38	4 December 1972	The Use of Supplementary Receivers for Enhanced Positional Accuracy in the DAB System	E. J. Kelly

1973-7	9 February 1973	A Maximum-Likelihood Multiple-Hypothesis Testing Algorithm, with an Application to Monopulse Data Editing	E. J. Kelly
1973-44	18 December 1973	Azimuth – Elevation Estimation Performance of a Spatially Dispersive Channel	T. P. McGarty
1973-48	26 September 1973	An Optimum Interference Detector for DABS Monopulse Data Editing	R. J. McAulay T. P. McGarty
1974-7	25 February 1974	Models of Multipath Propagation Effects in a Ground-to-Air Surveillance System	T. P. McGarty
1974-12	12 March 1974	False Target Elimination at Albuquerque Using ARTS-III Software	A. G. Cameron
1975-6	17 July 1975	Effects of Local Terrain and Obstacles Upon Near Horizon Gain of L-Band Beacon Antennas	A. Spiridon
1975-11	25 March 1975	The Statistical Characteristics of Diffuse Multipath Radiation and Its Effect on Antenna Performance	T. P. McGarty

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